Variation of Short-Scale Waves in the Shoaling Zone

P.I.: Douglas Vandemark
NASA/GSFC
Laboratory for Hydrospheric Processes
Bldg. N-159
Wallops Island VA 23337
Phone: (757) 824-2038 Fax: (757) 824-1036 email: vandemark@gsfc.nasa.gov
Award #: N0001497F0179

LONG -TERM GOAL

Goals are to provide measurements of short-scale sea surface roughness in the shoaling wave zone, determine the correlation between this short-scale slope variance and surface wind stress, and finally suggest the ramifications to microwave remote sensing in the shoaling zone.

SCIENTIFIC OBJECTIVES

Primary objective is to determine the characteristics of near-vertical incidence millimeter-wave radar backscatter over the surf zone and out to sea using aircraft radar measurements collected from the NOAA Long-EZ. This radar information relates directly to an integration of the sea surface spectrum over wave scales from swell down to 1 cm but with heavy weighting towards horizontal scales less than a few meters. These short-scale waves are known to be well-coupled to the wind stress. We have also shown success in measuring the slopes of the intermediate scale waves using a three laser ranging system aboard(see the report of T. Crawford). Thus our objectives have expanded to addressing the correlation between intermediate and short scale wave characteristics and the atmospheric turbulence data collected using the LongEZ. Our air and sea data are also being used to support SAR investigations of boundary layer signatures.

APPROACH

A simple down-looking Ka-band scatterometer (DLS) has been built and installed on the NOAA LongEZ research aircraft. High spatial resolution (< 1 m) radar backscatter data are being related to the small-scale surface slope using two-scale ocean scattering models. These measurements are highly complementary to the longer-wave slope data being derived from the LongEZ's laser sensors. Combined, the data can describe the variability of wave slope variance in the coastal zone. Knowledge of the slope variance is vital to the investigation of air-sea coupling and to proper understanding of scatterometer, SAR and radiometer measurements of the ocean surface.

WORK COMPLETED

The radar system has been built and then operated successfully in several pilot projects leading up to the Nov. 1999 Shoaling Waves Experiment (SHOWEX) to be conducted off of Duck N.C. Minor improvements to the initial design have been made. Radar data from the pilot experiment of 1997 have been processed and distributed to the research team. Necessary internal and

Report Documentation Page

Form Approved
OMB No. 0704-0188

Public reporting burden for the collection of information is estimated to average 1 hour per response, including the time for reviewing instructions, searching existing data sources, gathering and maintaining the data needed, and completing and reviewing the collection of information. Send comments regarding this burden estimate or any other aspect of this collection of information, including suggestions for reducing this burden, to Washington Headquarters Services, Directorate for Information Operations and Reports, 1215 Jefferson Davis Highway, Suite 1204, Arlington VA 22202-4302. Respondents should be aware that notwithstanding any other provision of law, no person shall be subject to a penalty for failing to comply with a collection of information if it does not display a currently valid OMB control number.

1. REPORT DATE	2. REPORT TYPE	3. DATES COVERED
30 SEP 1999		**00-00-1999 to 00-00-1999**

4. TITLE AND SUBTITLE	5a. CONTRACT NUMBER
Variation of Short-Scale Waves in the Shoaling Zone	5b. GRANT NUMBER
	5c. PROGRAM ELEMENT NUMBER
6. AUTHOR(S)	5d. PROJECT NUMBER
	5e. TASK NUMBER
	5f. WORK UNIT NUMBER
7. PERFORMING ORGANIZATION NAME(S) AND ADDRESS(ES) **National Aeronautics and Space Administration (NASA),NASA/Goddard Space Flight Center,Laboratory for Hydrospheric Processes, Bldg. N-159,Wallops Island,VA,23337**	8. PERFORMING ORGANIZATION REPORT NUMBER
9. SPONSORING/MONITORING AGENCY NAME(S) AND ADDRESS(ES)	10. SPONSOR/MONITOR'S ACRONYM(S)
	11. SPONSOR/MONITOR'S REPORT NUMBER(S)

12. DISTRIBUTION/AVAILABILITY STATEMENT
Approved for public release; distribution unlimited

13. SUPPLEMENTARY NOTES

14. ABSTRACT

15. SUBJECT TERMS

16. SECURITY CLASSIFICATION OF:			17. LIMITATION OF ABSTRACT	18. NUMBER OF PAGES	19a. NAME OF RESPONSIBLE PERSON
a. REPORT **unclassified**	b. ABSTRACT **unclassified**	c. THIS PAGE **unclassified**	**Same as Report (SAR)**	**3**	

external calibration of the radar has been performed to assure data quality.

Substantial effort has gone into calibrating and analyzing the surface slope measurements made with the three laser altimeters aboard the Long-EZ. These lasers combine to provide a sort of vector slope gauge and the fidelity of the 2-D slope data is quite promising.

Several conference proceeding publications were produced related to the surface wave measurements. A particularly promising example of the combined capability of the LongEZ's sensors for air-sea research came in our underflight of the RADARSAT SAR in Nov. 1997 during a cold air outbreak. An abstract from that study is given in the next section.

RESULTS

Abstract from Vandemark et al., submitted 1999:

A synthetic aperture radar (SAR) image was acquired by the Canadian Space Agency's RADARSAT over the mid-Atlantic bight on Nov. 5 1997. Widespread streaking in the image suggests the surface impacts of atmospheric boundary layer rolls. A research aircraft was flown about the SAR image region near the time of satellite passage and at an altitude of 15-20 m above the sea surface. Aircraft sensors measured near-surface atmospheric turbulence and, at the same time, variations in sea surface roughness using laser and radar. The aircraft turbulence observations clearly indicate a coherent secondary flow consistent with boundary layer rolls of crosswind scale 1.5-2.0 km. Modulation in measured laser and radar-inferred sea surface slope variance occurs at similar scales. Remarkable correlation is found between the radar backscatter and near-surface wind speed data showing that the short-wave slope variance is responsive to the local eddies. These aircraft results then indicate that the dominant term dictating SAR backscatter modulations due to roll vortices at these spatial scales is the fluctuation of the along-wind velocity associated with regions of near-surface convergence or divergence. Wind speed fluctuations of 7-10% estimated from the SAR and aircraft radar are consistent with the measured variations in near-surface wind speed. Finally, differentiation between short and intermediate scale wave roughness using aircraft laser and radar data leads us to conclude that observed fluctuations in intermediate-scale wave slope were not directly linked to the local wind. We can not exclude the possibility that these longer waves may still play a part in observed scales of O(2-4km) in the SAR imagery.

IMPACT

We expect the overall impact of these results to come in an improved understanding of how to better use microwave remote sensing in the shoaling zone.

TRANSITIONS

A NASA-funded LongEZ field experiment addressing altimeter electromagnetic bias determination was conducted Nov. 1998 near Duck, NC. Equipment and techniques developed for ONR's Shoaling Waves Initiative were utilized. This data collection was in support of the

Jason-1 altimeter program of NASA and the French space agency CNES.

RELATED PROJECTS

As mentioned above, this work is directly related to the NOAA LongEZ shoaling zone activities headed by J. Sun (cf. Sun:N00014-0-98-1-0245, Mahrt:N00014-0-98-1-0282, and Crawford:N00014-97-F-0123). This work is also closely related to NASA's Office of Earth Science research efforts to improve estimation of ocean sea level and wind speed as extracted from satellite altimeters, scatterometers and radiometers.

PUBLICATIONS

Mourad P. D., D. R. Thompson and D.Vandemark, Towards extracting fine scale wind fields from synthetic aperture radar images of the ocean surface, submitted to Johns Hopkins APL Technical Digest, June, 1999.

Vandemark, D., P. D. Mourad, T. L. Crawford, C. A. Vogel, J. Sun, S. A. Bailey and B. Chapron, Measured changes in ocean surface roughness due to atmospheric boundary layer rolls', submitted to JGR-Oceans, 1999.

Vandemark, D. , P. Mourad, T. Crawford, C. Vogel, 'Measured correlation between roll-vortex signatures and radar-inferred sea surface roughness', Proceedings of IGARSS, Hamburg, 1999.

Vandemark, D. , T. Crawford, R. Dobosy, T. Elfouhaily and B. Chapron, 'Sea surface slope statistics from a low-altitude aircraft', Proceedings of IGARSS, Hamburg, 1999.

Palm, S. P., G. K. Schwemmer, D. C. Vandemark, K. Evans and D. O. Miller, The estimation of surface latent heat flux over the ocean and its relationship to Marine Atmospheric Boundary Layer (MABL) structure', Proceedings of SPIE, Denver, 1999.

R. Dobosy, T. L. Crawford, D. C Vandemark, and C. A Vogel, 'Measurement of ocean surface in shoaling zones by laser array and Ka-band radar', Proceedings of 4th Intl. Airborne Rem. Sensing Conf., 1, 66-73, 1999.